

Volume Growth Loss: A Hidden Cost of Periodic Prescribed Burning in Longleaf Pine?

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ABSTRACT. The influence of understory hardwood control treatments, including periodic prescribed burning, on the growth of longleaf pine (*Pinus palustris*) was monitored over a 10-yr period. Treatments, established in 14-yr-old sapling stands thinned to 500 trees/ac, included biennial prescribed burns in (1) winter, (2) spring, (3) summer, and (4) an unburned check. Each of these was combined with three supplemental treatments: (1) initial chemical treatment of all hardwood stems, (2) repeated handclearing of all woody stems, and (3) no treatment. All measures of pine growth were significantly reduced by the burns. Pine volume growth over the first 7 years on unburned plots exceeded the average on burned plots by 23% (24 ft³/ac/yr). During the next 3 years, volume growth on unburned plots exceeded the average on burned plots even more—by 33% (44 ft³/ac/yr). Supplemental treatments did not affect pine growth, even though plots without these treatments developed hardwood stands (>1.5-in. dbh) ranging from 4.0 ft² basal areal/ac with summer burns to 11.6 ft² on unburned plots.

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Understory vegetation, especially hardwoods and other woody plants, may reduce the growth of overstory pine, particularly at young ages. Longleaf pine seedlings seem to be more sensitive to competition from all sources than any of the other southern pines. Assuming that the species' intolerance of competition does not diminish with age, elimination of understory hardwoods should promote a positive growth response at least as great as that observed in other pines. Unfortun-

nately, little information is available on longleaf pine growth in relation to competition control beyond the seedling stage.

A number of reports (for example, Clason 1978, Loyd et al. 1978, Cain and Mann 1980) indicate that reduction or elimination of understory hardwoods will boost the growth of southern pines. Further, controlling hardwoods and other competing vegetation is the goal of most cultural operations in pine management. These operations include: (1) mechanical treatments, usually for preplanting site preparation, (2) chemical herbicides, for either site preparation or release, and (3) periodic prescribed fire, which can prevent or retard the encroachment of hardwoods into pine stands. Costs of these treatments are usually justified by expected increases in pine volume yields.

Prescribed fire is by far the least expensive treatment for control of understory hardwoods in pine stands. However, possible long-term damage to overstory pines from periodic prescribed burning has not been adequately investigated. Hints from the past (MacKinney 1931, Bruce 1947) suggest that prolonged annual burning in young longleaf pine could reduce both height and diameter growth. More recently, in conjunction with thinning and burning treatments, the more heavily thinned stands of pole-sized longleaf pine had greater diameter growth on unburned than on burned plots, al-

though the pattern was reversed on lightly thinned or unthinned plots (Van Lear et al. 1977). Planted slash pine burned in March or May at 1-, 2-, and 3-year intervals beginning at age 4 resulted in significant reductions in height growth compared to similar unburned stands (Grelen 1983). Conversely, increased diameter and height growth in 9-year-old slash pine was associated with burning, although this favorable growth response was reduced by crown scorch (Johansen 1975). Reduction in height and diameter growth of nine-year-old loblolly pines during the year after burning was significantly related to degree of crown scorch (Cain 1985). Stands of pole-sized loblolly pine burned at different seasons experienced no detrimental effect on either their survival or growth, provided crown scorch was moderate or less (Waldrop and Van Lear 1984). Also, periodic burning in mature longleaf and loblolly pine stands had no effect on growth of the pine overstory (Sackett 1975).

Generally, southern pines beyond the sapling stage are considered immune to damage from low intensity surface fires if there is little or no crown scorch. Longleaf pine, having a long history of natural association with—and even dependence on—periodic fires, is considered more resistant to fire damage than any of the other southern pines.

THE STUDY

A study was initiated in 1973 to determine the effects of several understory hardwood control treatments on the growth of young stands of longleaf pine, and on the composition and structure of the understory. The study was established on sandy, upland coastal plain soils on the Escambia Experimental Forest¹ in south-

¹ Maintained by the Southern Forest Experiment Station, USDA Forest Service, in cooperation with the T. R. Miller Mill Company.

western Alabama. The predominant soil type was Troup fine sand. At the time of establishment, all study areas supported well-stocked natural stands of longleaf pine averaging about 700 trees per acre. The young pine stands had grown for 12 years after parent overstory removal, and were 14 years old from seed.

Three blocks, each with 12, square, 0.4-ac plots, were established for this study. All plots were thinned to about 500 dominant pines per acre. The 50 (average 50.3) pines in each central 0.1-ac square net plot were marked and numbered, and total height and dbh recorded. The residual pines in thinned stands averaged 22 ft in height, 3.2 in. dbh and 30 ft² basal area/ac. Estimated age 50 site index (Farrar 1981a) on the three blocks, based on dominant/codominant tree height on unburned plots at age 24, averaged 71, 76, and 78 ft.

Twelve treatment combinations were randomly assigned among plots in each block. Four fire treatments [biennial prescribed fires in (1) winter, (2) spring, (3) summer and (4) unburned check] were each combined with three supplemental treatments [(1) treat all woody stems with 2,4-D at time of study establishment, (2) hand-clear all woody vegetation 4½ ft or more in height at 2-year intervals, and (3) no treatment]. Treatments continued throughout the entire period of study. Sixty percent of all plot burning was done with strip head fires, 24% with backfires, and the remainder with flank fires. Pertinent weather and fire behavior factors were recorded when each plot was burned. Crown scorch was not recorded because the observed scorch level following the burns appeared too light to cause damage.

Net plots were first remeasured in the winter of 1980, after 7 growing seasons. In addition to marked pines, all hardwoods in the 2-in. dbh class (>1.5 in. dbh) and larger were measured. Three years later, in the winter of 1983, all plots were similarly remea-

Table 1. Effect of cultural treatments on average annual volume growth of overstory pine over seven years (1973–1979).

Supplemental treatment	Season of burn				Average
	Winter	Spring	Summer	None	
	(ft ³ /acre, i.b.)				
Chemical	95	92	135	116	110
Mechanical	99	103	89	133	106
None	112	113	73	125	106
Average	102a ¹	103a	99a	125b	107

¹ Row means followed by same letter not significantly different at 0.05 level, according to Duncan's test.

sured. Total cubic foot volumes (inside bark) of pine were obtained from dbh and height using a longleaf pine volume equation (Farrar 1981b). Hardwood cubic foot volumes (inside bark) were obtained from dbh using a local (unpublished) Experimental Forest volume table.

At each of the three examinations, the composition, structure, and biomass (by component) of understory vegetation were sampled on 9 (3.1 ft²) subplots in each net plot. This included counts of all woody stems 1.5 in. dbh or less.

TREATMENT AND PINE GROWTH

Seven years after study establishment, sample trees averaged 40 ft in height and 4.6 in. dbh, with 485 survivors and 60 ft² basal area/ac. As reported earlier (Boyer 1983), every burning treatment significantly reduced all recorded measures of pine growth (height, diameter, basal area, volume) over that in the unburned check. Surprisingly, season of burn had no effect. The impact of periodic summer burns was not significantly different from that of winter or spring burns. Although both the chemical and hand-

clearing treatments effectively eliminated all hardwoods (>1.5-in. dbh), these treatments had not significantly improved pine growth over that in untreated plots. Over the 7 years, annual total volume growth of pine on unburned plots averaged 125 ft³/ac, which exceeded the average on all burned plots by nearly 24 ft³, and represented a 23% increase (Table 1).

At the next remeasurement, 3 years later, sample trees averaged 45 ft in height and 5.1 in. dbh, with 482 survivors and 75 ft² basal area/ac. Pine growth for the 3 years was significantly reduced by burning treatments, but unaffected by season of burn. Supplemental treatments still did not significantly affect pine growth. The effects of burning on pine volume growth during the 3 years was substantially greater than it was before. For the 3 years, annual total volume growth of pine on unburned plots averaged 179 ft³/ac, which exceeded the average on burned plots by 44 ft³, a 33% increase (Table 2).

Ten-year diameter, height, basal area, and volume growth were significantly affected only by the prescribed burning treatments

Table 2. Effect of cultural treatments on average annual volume growth of overstory pine over three years (1980–1982).

Supplemental treatment	Season of burn				Average
	Winter	Spring	Summer	None	
	(ft ³ /ac, i.b.)				
Chemical	129	147	141	188	151
Mechanical	119	136	145	172	143
None	144	145	108	175	143
Average	130a ¹	143a	131a	179b	146

¹ Row means followed by same letter not significantly different at 0.05 level, according to Duncan's test.

Table 3. Effect of biennial prescribed burns on growth of pine stands over ten years (1973–1982).

Season of burn	Ten-year growth			
	dbh	Height	Basal area/ac	Vol/ac (ib)
	(in.)	(ft)	(ft ²)	(ft ³)
Winter	1.87a [†]	22.1a	43.3a	1106a
Spring	1.85a	22.3a	44.3a	1149a
Summer	1.91a	22.6a	42.2a	1086a
No burn	2.16b	24.9b	53.0b	1409b

[†] Column means followed by same letter not significantly different at 0.05 level, according to Duncan's test.

Table 4. Midstory hardwood stand (>1.5 in. dbh) development on plots without supplement treatments.

Season of burn	Trees/ac		Basal area/ac		Vol./ac (ib)	
	1980	1983	1980	1983	1980	1983
	(no.)		(ft ²)		(ft ³)	
Winter	190	237	6.3	8.7	76	102
Spring	153	113	5.2	5.1	65	59
Summer	90	97	3.2	4.0	38	45
No burn	287	307	9.5	11.6	122	145

(Table 3). Initial differences in pine height, dbh, basal area, and volume had no effect on the results, according to an analysis of covariance.

Pine mortality over the 10 years was relatively low, averaging 4.3%. However, mortality with the summer burn treatment, at 8.0%, significantly exceeded mortality with the other 2 burning treatments and the check, which did not differ among themselves. The excessive mortality was confined to the summer burn-check treatment combination in all three blocks. Average initial dbh of the dead trees was the same as the survivors. Mortality in the other two summer burn treatments was less than the average for all treatments combined. There was no apparent reason for this result. Most of the mortality (84%) occurred during the first 7 years.

HARDWOOD DEVELOPMENT

Before treatment, the density of midstory hardwoods (those trees >1.5 in. dbh) on study plots averaged an estimated 3.6 ft² basal area/ac. Stem counts of these hardwoods were not made. Stems of tree species 1.5 in. dbh or less were counted on subplots and averaged 5.3 thousand/ac.

The chemical and handclearing treatments eliminated all midstory hardwoods and none had returned by the 1983 remeasurement. Hardwood midstory characteristics in 1980 and 1983 on plots without supplemental treatments are given in Table 4. Hardwoods developed most rapidly with the no-burn and winter-burn treatments. A slight decline in numbers occurred with the spring burn and a slight increase with the summer burn. On the unburned plots, midstory hardwoods in 1983 comprised about 12% of total basal area and 8% of total volume (Figure 1). So far, there is no indication that these hardwoods are having any effect on the growth of overstory pine.

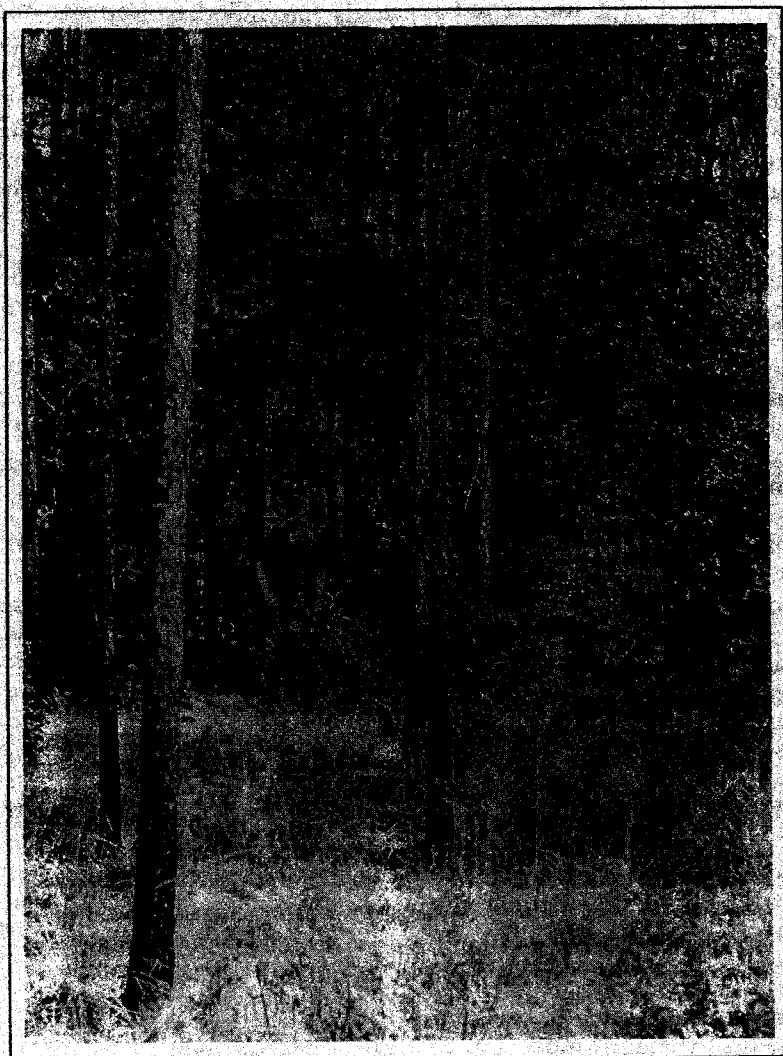


Figure 1. Biennial spring burns plus chemical treatment, foreground; unburned check, background.

MANAGEMENT IMPLICATIONS

The extent to which results of this study may apply to other southern pines, or different sites, is not known and will require further investigation. In this study, biennial prescribed burns in young longleaf pine stands on sandy coastal plain soils reduced pine growth substantially from that observed in similar, unburned, stands. Furthermore, the impact of the fire treatments appears to be worsening with time. Will the growth rate differential between burned and unburned stands continue to increase, or will it eventually stabilize and decline as stands mature? Older stands may respond similarly according to preliminary results from an identical series of burning treatments established in mature longleaf pine stands. Dbh growth of unburned stands was 12% greater than the average for all burned stands over the 10-year period from age 50 to 60 years.² This compares to the dbh growth differential of 14.6% recorded in the study reported here.

It is not known why burning has so seriously reduced the growth of this comparatively fire-resistant species. Fire intensities, based on recorded flame lengths, were low, ranging from 10 to 343 but averaging less than 150 Btu/ft/sec, in part because frequency of burning kept fuel accumulations low. Intensities of recorded summer burns never exceeded 100 Btu/ft/sec. Many past studies of prescribed burning on southern coastal plain soils (Hough 1981, McKee 1982) have not revealed any adverse effect of moderate to low intensity fires on soil structure or chemistry. In some instances, the growth environment for trees is improved through more rapid

nutrient cycling. Perhaps some unknown interactions between burning and other environmental factors are responsible. Possibly the frequency of burning is causing damage that would not occur with longer intervals between fires. Further research is needed to determine the causes for the observed pine growth loss.

Burning, especially during the growing season, reduced the density of midstory hardwoods, while hand-clearing and chemical treatments eliminated them entirely. Reduction or elimination of hardwoods has failed to improve the growth of overstory pine. Perhaps dominant pine stands can tolerate hardwoods up to the density observed in this study without adverse effects on growth. Alternatively, drought stress during the 10-year period of observation may not have been severe enough to create detectable competition between pine overstory and hardwood understory.

So far, results of this study have shown no sign of a "payoff," in terms of improved pine growth, for investments in burning or other cultural treatments to control understory hardwoods. The very considerable potential costs arising from volume growth losses associated with periodic prescribed burning must be considered in any economic evaluation of this practice. Payoffs for hardwood control, if any, may come through improved accessibility, greater herbaceous plant cover, and reduced site/seedbed preparation costs at a rotation's end. If, by that time, understory hardwoods have commercial value for pulp or fuelwood, there may be little justification for control during the rotation. □

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² Unpublished data on file, G. W. Andrews Forestry Sciences Laboratory, Auburn University, AL.